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# DETERMINANTS OF TECHNICAL INEFFICIENCY AMONG MAIZE-BASED FARMING HOUSEHOLDS IN NIGER STATE, NIGERIA

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**Abstact**

*Examining the level of farm-specific technical inefficiency of maize-based farming households in Niger state of Nigeria, this study fitted cross-sectional data into a Cobb- Douglass production frontier. Data used for this study were obtained using structured questionnaire administered to 108 randomly selected maize-based farming households. Descriptive analysis and the stochastic frontier production function methodology were used to achieve the research objectives. The mean technical inefficiency is 0.357 (35.7%), implying that about 36% percent efficiency gap from the optimum (100%) was yet to be attained by all Niger State maize-based farming households. The main determinants of technical inefficiency among the households are farm income, crop production intensification and market access. Policy that would promote adoption of hybrid seeds and other inputs as well as facilitate the development of infrastructures such as roads and market facilities among farming households are therefore encouraged. The government policy of subsidizing hybrid maize seeds and fertilizers is consistent with the findings of this study.*

**Keywords:** *Productivity, stochastic frontier model and crop production intensification.*

## Introduction

In Nigeria, agriculture is made up of forestry, livestock, fishing, food and cash crops such as yams, cassava, maize, cocoa, groundnut and oil palm. The country is largely endowed with natural resources that are necessary for the development of agriculture-such resources include abundant land supply, human and forestry resources. The country has a total land area of about 98.3 million hectares out of which 71.2 million hectares (72.4%) are cultivable but only 34.2 million hectares (34.8%) are under use (Daramola, 2004). Agricultural production is still highly dominated by the small holder farming system. The farms are dominated by small scale farmers who are responsible for about 95% of total production (Awoyemi, 1981). This is not unconnected with the unattractiveness of agriculture which is a result of lack of necessary infrastructures in the rural areas which forms the bulk of agricultural zones in the country. In addition, small scale agriculture has in the time past suffered from limited access to credit facilities, modern technology farm inputs and inefficient use of resources. Nevertheless, it is on record that 50% of world's population is dependent on subsistence agriculture (Dillon and Hardaker, 1986).

Maize is a major cereal consumed by nearly all Nigerian households. It has great dietary and economic importance. Since the 19th century, maize has become the prime source of grain for feeding monogastic animals especially in those parts of the country where cassava cannot be grown (Guy, 2001). Apart from animal feeding, it is the key to agro-allied industrial raw materials from which many products are manufactured. With regards to food, processed maize is used in several ways. It can be eaten as roasted or boiled; it can also be cooked along with beans. In some local areas, it can be pounded along with yams, cocoyam and water-yams. As a result of the different uses into which maize can be put, there has been an increase in its demand over the years. Akande 1994, reported that the domestic demand of 3.5m metric tonnes far outstripped domestic production of 2.0m metric tonnes, hence the increase in its price.

To stem the tide of the current food problem through crop production intensification which according to Tiffen et al., (1994); is the use of increased average inputs on smallholding for the purpose of increasing the value of output per hectare. The Federal government in 2006 initiated a programme of doubling maize production in Nigeria through promotion of improved production technologies such as fertilizer, hybrid seeds, pesticides, herbicides and better management practices. Since then, several stakeholders have alleged their support for this program. Several improved maize varieties,

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drought tolerant, low nitrogen-tolerant, Striga-tolerant, stem-borer-resistant and early maturing, have been deployed to address the challenge faced by resource-poor farmers in maize production. However, the available studies on the productivity gains in maize production in Nigeria suggest little improvement in productivity and the goal of self-sufficiency in food production remains a long-term target (Oluwatayo et al. 2008; Oyewo et al. 2009). One of the reasons often attributed to decline in productivity is depletion in soil fertility primarily resulting from poor production practices characterized by low use of modern inputs. Also, a series of studies have been carried out to assess technical efficiency and its drivers in Nigeria, which include: Okike *et. al.;* (2001); Ajibefun and Daramola (2003); Rahji (2005); Amaza *et al*. (2008). None of the aforementioned studies, however, has assessed intensification as a driver of technical inefficiency. Thus, this study analyzed the determinants of technical inefficiency among maize-based farming households with the aim of finding ways to increase production and productivity in the study area.

## Methodology

### *Study Area*

The study was carried out in Niger State, in the Southern Guinea Savanna of Nigeria. Niger State lies between longitude 8°11' and 11°20' north of the equator and between 4°30' east of the equator. It covers an estimated land area of 4240 km sq. The vegetation of the state is mainly Southern Guinea Savanna. The annual rainfall ranges between 1110 mm in the north to 1600 mm in the south with a mean of 1200mm. The rain starts in late April and ends in October with the peak being in July. The average minimum temperature is about 26°C while the average maximum temperature is about 36°C. The mean humidity ranges between 60 (January to February) and 80% (June to September). The vegetation supports the cultivation of root crops and grains. The predominant crops are; maize, rice, sorghum, millet, yam, groundnut and cotton.

### *Sampling Procedure and Sample Size*

The target population for this study is the maize-based farming households in Niger state. A two-stage sampling technique was used to select sample for the study. The first stage involved the random selection of 5 villages from each of the three ADP zones in the state. The Agricultural Development Projects (ADPs) village listing served as the sampling frame for the selections in the state. In each village, 10 farming households were randomly selected among the farming households in the area to make up a sample size of 150. However, only 108 questionnaires were retrieved and analyzed.

### *Analytical Techniques*

Descriptive and inferential statistics as well as Cobb–Douglas stochastic production frontier approach was used to estimate the production function and the determinants of technical inefficiency among maize-based farming household. Given the potential estimation biases of the two-step procedure for estimating technical efficiency scores and analysing their determinants, the one-stage procedure is adopted following Battese and Coelli (1995). Although this approach has its own limitations, it remains one of the popular production functions in production frontier studies. The following model is estimated on the basis of the Battese and Coelli (1995) procedure:

$$Yi = Xi\beta + (Vi - Ui),\ i = 1, N, \text{-----------} (1)$$

Where $Y_i$ is the output of maize crop in grain equivalent. Xi is a k x 1 vector of input quantities of the $_i$th household (land is measured as the total plot area cultivated in hectares; and labour is estimated as man-days worked; fertilizer is the amount of fertilizer used on the plot in kilogram; seed is the quantity of seed in kilograms, regardless of the type of maize and agrochemicals is the quantity of chemicals used in liters). β is a vector of unknown parameters to be estimated: Where Vi are random variables, two-sided ($-\infty < vi < \infty$) normally distributed random error N ~ (0,δv2), which are assumed to be independent of the Ui that captures the stochastic effects outside the farmer's control (e.g., weather, natural disasters, and luck, measurement errors in production, and other statistical noise).

The two components v and u are also assumed to be independent of each other. Thus, to estimate a Cobb-Douglas production functions, we must log all the input and output data before the data is analyzed (Coelli, 1995). The estimating equation for the stochastic function is given as:

$$\ln Y = \beta 0 + \beta 1\ln X1 + \beta 2\ln X2 + \beta 3\ln X3 + \beta 4\ln X4 + \beta 5\ln X5 + Vi - Ui \text{ -----}(2)$$

The maximum likelihood estimation of equation yields consistent estimators for β, the variance parameters; gamma (γ), lambda (λ) and Sigma squared ($\delta^2$).

***Determinants of Technical Inefficiency***

$U_i$ =Inefficiency component of error term. It is assumed that the inefficiency effects are independently distributed and Ui truncation (at zero) of the normal distribution with means 0 and variance $\sigma^2u$ where Ui is specified as:

$U_i = \delta o + \delta i Z_{1i} + \delta_2 Z_{2i} + \delta_3 Z_{3i} + \delta_4 Z_{4i} + \delta_5 Z_{5i} + \delta_6 Z_{6i}$---------------------(3)

Where

$U_i$=Technical inefficiency of maize-based farming household.

$Z_{1=}$ Extension contact was based on the number of visits by the extension agent.

$Z_{2=}$ Level of Education measured by a dummy. 1 if the household head has formal education and 0 if otherwise.

$Z_{3=}$ Farm Income in Naira.

$Z_{4=}$ Crop Production Intensification which was measured using Shriar, (2005) index.

$Z_{5=}$ Farm Distance in kilometers.

$Z_{6=}$ Market Distance measured in kilometers

***Elasticity of Production and Return to Scale Measurement***.

Other estimates derived from our stochastic equation (2) for maize–based farming household in the study area are elasticity of production (EOP) and return to scale (RTS). EOP is the same as the estimated coefficients of the independent variables (Kumbhakar, 1994).

RTS=∑EOPi i = ---------,n-----------(4)

Inferentially, RTS < 1, decreasing return to scale

RTS > 1, increasing return to scale

## Results and Discussion

***Socio-economic characteristics of Farming Households***

The farming household's socio-economic characteristics are summarized in Table 1. About Ninety one percent of the household head were male, against only 9 percent of female. The age of the households' heads ranged between 30 and 75 years with an average of 48.3 years. This implies that the household's heads are still in their active ages. The average year of experience was 28.9 years. This indicates that most of the household' heads have been practicing farming for long. The accumulated years of experience may help farming households' heads in crop selection and enable them to evolve the farming practices that are most suitable to their fragile environment. The average household size is 11 persons in the state. Most (68.3%) households are polygamous in nature. Polygamous nature of the people probably explains the large family size recorded in the area. Household size is used as a proxy for labour because individual in the household is a potential source of labour. Their availability reduces labour constraints faced during the peak of the farming season. (TeckleWorld et. al., 2006). Majority (65.7%) of the household heads are predominantly farmers, while others were involved in both agricultural and non-agricultural trading, business and civil service as their secondary sources of livelihood. This result has effect on the cropping practices adopted and also enhances the intensity with which agricultural land is used.

Majority of the farming household heads (81.9%) are literate with most of them having Quranic education (38.9%) and this is closely followed by primary education (36.1%) Those who had tertiary education (1.9 %) probably constituted the civil servant who engaged in part-time farming in the area. Given this level of literacy it is expected that information can be disseminated with ease among these households' heads. Basically, the levels of education of households' heads have significant impact on productivities, income earning opportunities and ability of farming households heads to effectively adopt better management practices. Eight crop combinations were popular among the sampled household heads. Maize intercropped with cowpea had the largest number of occurrence (33.3%). This may be due to the easy adaptation of maize and cowpea to the environment. Maize-sorghum mix, maize-millet mix, maize-cassava mix, and maize-yam mix were the second, third, fourth and fifth widely adopted crop mixtures. Other crop mixtures are sole maize, maize-okro mix and maize-okro-tomatoes mix.

Table 1 Socio-economic Characteristics of the Household Heads

| Variables | Frequency | Percentage |
|---|---|---|
| i) Age of the Household Head | | |
| 21-40 years | 24 | 22.2 |
| 41-60 years | 71 | 65.7 |
| 61-80 years | 13 | 12.1 |
| Total | 108 | 100 |
| ii)Sex of the Household Head | | |
| Male | 98 | 90.7 |
| Female | 10 | 09.3 |
| Total | 108 | 100.0 |
| iii)Marital Status of the Household Head | | |
| Married | 94 | 87.0 |
| Single | 10 | 09.3 |
| Widower/Separated | 04 | 03.7 |
| Total | 108 | 100 |
| iv)Household Size | | |
| 1- 5 | 06 | 05.5 |
| 6- 10 | 46 | 42.6 |
| 11-15 | 48 | 44.4 |
| 16-20 | 08 | 07.4 |
| Total | 108 | 100.0 |
| v)Education Status of the Household Head | | |
| No formal Education | 17 | 15.7 |
| Quranic Education | 42 | 38.9 |
| Primary Education | 39 | 36.1 |
| Secondary Education | 09 | 08.3 |
| Tertiary Education | 02 | 01.9 |
| Adult Education | 03 | 02.8 |
| Total | 108 | 100.0 |
| vi)Primary Occupation of the Household Head | | |
| Farming | 71 | 65.7 |
| Agricultural Trading | 19 | 17.6 |
| Non-Agricultural Trading | 07 | 06.5 |
| Business | 08 | 07.4 |
| Civil Service | 03 | 02.8 |
| Total | 108 | 100.0 |
| vii)Farming Experience of the Household Head | | |
| 1- 10 | 07 | 06.5 |
| 11-20 | 21 | 19.4 |
| 21-30 | 34 | 31.5 |
| 31-40 | 30 | 27.8 |
| 41-50 | 16 | 14.8 |
| Total | 108 | 100.0 |
| viii)Crop/Crop Mixtures | | |
| Sole Maize | 08 | 07.4 |
| Maize/ Cowpea | 36 | 33.3 |
| Maize/ Sorghum | 15 | 13.9 |
| Maize/ Cassava | 10 | 09.3 |
| Maize/Millet | 14 | 12.9 |
| Maize/ Yam | 09 | 08.3 |
| Maize/ Cassava/Yam | 05 | 04.6 |
| Maize/ Okro/Tomatoes | 04 | 03.7 |
| Maize/ Sorghum/Okro | 04 | 03.7 |
| Maize/ Okro | 03 | 02.8 |
| Total | 108 | 100 .0 |

***Technical Inefficiency Analysis of Niger State Maize-Based Farming Households***

The expected parameters and the related statistical test results obtained from the analysis of the MLE of the Cobb-Douglass based stochastic frontier production function parameters for the Niger State farming households are presented in table 2.

The gamma ($\gamma$) ratio of 0.9999 which is significant at 1% level implied that about 99.999 percent variation in the output of the Niger State maize-based farming households was due to differences in their technical efficiencies. Lambda ($\lambda$) estimated at 28.35 which is greater than 1 indicates a good fit and the correctness of the specified distributional assumption of the composite error term (Tradesse and Krishmamooorthy, 1997). The coefficient of fertilizer and land are both significant at 1% and 5% level of probability respectively. The estimated coefficient of fertilizer was positive, which conform to a priori expectation. This implies that as the respondents increase the use of fertilizer, *ceteris paribus*, maize- based output increases (Table 2). This implies that availability of fertilizer at affordable price generally determines the increase in land under maize production in any particular year in the zone. Thus areas cultivated to maize decrease as fertilizer subsidies are withdrawn. Similar results were obtained by Oyewo et al. (2009) and Oluwatayo et al. (2008) among Oyo and Ekiti states maize-based farming households respectively. Also, the coefficient of land, though negative, is statistically significant at 5% level of probability. This suggests a situation of inappropriate (and hence, inefficient) use of this input in maize-based cropping systems in the study area. The coefficient of the two physical inputs: quantity of fertilizers and land are all significant. These are the major factors explaining maize-based production systems in the study area. On the other hand, the coefficient of labour, agrochemicals and seeds are not significant in explaining the variation in output among maize-based farming households in the study area.

Table 2 Maximum Likelihood Estimates of Stochastic Frontier Model for Niger State farming Households

| Variables | Parameters | Coefficient | t-values |
|---|---|---|---|
| Physical inputs | | | |
| Constant | $\beta_0$ | 0.4938*** | 3.280 |
| Land (ha) ($X_1$) | $\beta_1$ | -0.2918** | -2.243 |
| Labour (man-days)($X_2$) | $\beta_2$ | 0.1384 | 0.832 |
| Seeds (Kg) ($X_3$) | $\beta_3$ | 0.0070 | 0.047 |
| Fertilizer (kg) ($X_4$) | $\beta_4$ | 0.6730*** | 7.411 |
| Agrochemical (litres) ($X_5$) | $\beta_5$ | -0.0453 | -0.237 |
| Inefficiency model | | | |
| Constant term | $\delta_0$ | 0.1676 | 0.115 |
| Extension Contact ($Z_1$) | $\delta_1$ | 0.0148 | 0.681 |
| Level of Education ($Z_2$) | $\delta_2$ | 0.0288 | 0.491 |
| Gross Farm Income ($Z_3$) | $\delta_3$ | -0.1574*** | -9.652 |
| Crop Intensification ($Z_4$) | $\delta_4$ | -0.0254** | -2.191 |
| Farm Distance ($Z_5$) | $\delta_5$ | -0.7561 | 0.924 |
| Market Distance ($Z_6$) | $\delta_6$ | -0.4080** | -2.399 |
| Diagnostic statistics | | | |
| Sigma square ($\delta^2$) | ($\delta u^2 + \delta v^2$) | 0.0805 | 1.5646 |
| Gamma ($\gamma$) | ($\delta u^2 / \delta^2$) | 0.9999*** | 170.06 |
| Lambda | ($\delta u/\delta v$) | 28.35 | |
| Log-likelihood function | | | 0.6115 |
| Sample size (n) | | 108 | |

*** significant at 1%, **significant at 5%

***Determinants of Technical inefficiency of Niger State Maize-based Farming Households***

The result of the inefficiency model shows that the coefficient of crop production intensification is negative and statistically significant at 5% level of probability (Table 2). This implies that increased crop production intensification would reduce technical inefficiency of the sampled respondents. The coefficient of farm income is also negative and significantly related to technical inefficiency at

1% level of probability. Oyekale and Idesa (2009) reported similar findings among maize-based farming households in Rivers state, Nigeria.

The coefficient of market access is negative and significantly related to technical inefficiency at 5% level of probability. The farther the distance of farmhouse to the market, the lower the probability of using the hybrid maize seed in the zone. When households incur high transactions costs in marketing, the total production costs are increased and the product profit margins are reduced. Farmers closer to the markets had a high probability of using improved hybrid maize seed which in turn raises productivity. When farmers sell their agricultural produce competitively they are able to reduce the income constraint hence are able to purchase the external inputs that are required to increase agriculture productivity. Hau and Von Oppen (2002), found that a decrease in distance of farm to market by 10 per cent, increases intensification through fertilizer and pesticide use by 5.3 per cent and 0.4 per cent respectively.

The coefficient of education is positive but statistically insignificant, suggesting that better educated farmers produce maize inefficiently, which is contrary to expectations. One explanation is that maize is mainly produced for subsistence using traditional methods and the education of farmers does not play a role in the optimal combination of inputs. The coefficient of other variable such as farm distance had the expected sign that corresponds to literature review but is found not important in determining technical inefficiency of Niger state farming households.

***Elasticity of production inputs and returns to scale of Niger State Households***

The summation of elasticities obtained indicated a decreasing return to scale and that small scale maize-based production in the area was in stage II of the production function (Table 3).

The estimated elasticities of mean output with respect to fertilizer and land inputs were 0.6730 and -0.2918 respectively. This means that for 1% increase in fertilizer input, the output will increase by 0.6730%. On the other hand, a 1% increase in land input decreases output by 0.2918% .

Table 3 Estimated Elasticity of Factor Inputs and Return to Scale

| Variables | Coefficients (Elasticity of Production) |
|---|---|
| Land ($X_1$) | -0.2918 |
| Labour ($X_2$) | 0.1384 |
| Seeds ($X_3$) | 0.0070 |
| Fertilizer ($X_4$) | 0.6730 |
| Agrochemical ($X_5$) | -0.0453 |
| Return to scale | 0.4813 |

***Technical Efficiency Ranges for Niger State Maize-Based Farming Households***

The indices in table 4 showed that the technical efficiency of the sampled farming households was less than one (less than 100%), implying that all the maize based farming households in the study area were producing below the maximum efficiency frontier. Some farming households demonstrated a range of technical efficiency of 0.947 ((94.7%).

The mean technical efficiency is 0.643 (64.3%), implying that on the average the farming households were able to obtain a little over 64 percent of potential maize output from a given mix of production inputs. About 35.7 percent efficiency gap from the optimum (100%) was yet to be attained by all Niger State maize-based farming households.

Table 4 Distribution of Technical Efficiency Indices of Niger State Farming Households

| Efficiency class index | Frequency | Percentage |
|---|---|---|
| 0.11 – 0.20 | 1.0 | 00.78 |
| 0.21 – 0.30 | 7.0 | 05.51 |
| 0.31 – 0.40 | 11.0 | 08.66 |
| 0.41 – 0.50 | 13 | 10.23 |
| 0.51 – 0.60 | 15 | 11.81 |
| 0.61 – 0.70 | 20 | 15.74 |
| 0.71-0.80 | 11 | 08.66 |
| 0.81 – 0.90 | 34 | 26.77 |
| 0.91 – 1.00 | 15 | 11.81 |
| Total | 127 | 100.00 |
| Maximum value | 0.947 | |
| Minimum value | 0.165 | |
| Mean | 0.64.3 | |

Source: Computed from MLE Results

**Conclusion and Recommendations**

This study set out to estimate the determinants of technical inefficiency among maize-based farming households in Niger state, Nigeria. Since maize is the main staple food in Nigeria, high productivity and efficiency in its production are critical to food security and poverty alleviation in the country. The government has been investing in agricultural development since independence in 1960, but most households remain food insecure and aggregate maize production indexes do not show sustainable patterns in food production. The stochastic production function approach was used to estimate technical efficiency scores while simultaneously determining the factors that are associated with inefficiency among maize-based farming households. The econometric results based on the stochastic production function show that maize production is done under decreasing returns to scale. Many maize-based farming households are technically inefficient, with mean technical efficiency scores of 64.3% and technical scores as low as 16.5%. The mean efficiency levels are lower but comparable to those that obtain in other African countries whose means range from 55% to 79%. The results, however, support the hypotheses that technical inefficiency decreases with improve market access, crop production intensification and increased farm income. Despite the long history of government investment in the agriculture sector through extension services and promotion of technology, maize-based farming household remains technically inefficient. Two main policy issues emerge from the results of this study. First, there is need to promote adoption of hybrid seeds and other inputs among maize-based farming households. The government policy of subsidizing hybrid maize seeds and fertilizers is consistent with the findings of this study. Second, there is need to facilitate the development of infrastructures such as roads and market facilities among farming households in the study area.

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